International Journal of Recent Trends in Engineering & Research
ISSN(ONLINE) : 2455-1457
IMPACT FACTOR : 3.344

MYSTERIES DARK ENERGY AND UNIVERSE

Rajnivas.B[1], Devaneyan.S2
[1,2] Assistant Professor, PPG Institute of technology

Abstract: The nature of dark energy is one of the most important unsolved problems in all of science. Step backs a minute and considers a more familiar experience: what happens when you toss a ball straight up into the air? It gradually slows down as gravity tugs on it, finally stopping in mid-air and falling back to the ground. Of course, if you threw the ball hard enough (about 25,000 miles per hour) it would actually escape from the Earth entirely and shoot into space, never to return. But even in that case, gravity would continue to pull feebly on the ball, slowing its speed as it escaped the clutches of the Earth. But now imagine something completely different. Suppose that you tossed a ball into the air, and instead of being attracted back to the ground, the ball was repelled by the Earth and blasted faster and faster into the sky. This would be an astonishing event, but it's exactly what astronomers have observed happening to the entire universe. In this paper we are going to discuss the dark energy and universe.

Keywords : *Dark energy, Dark matter*

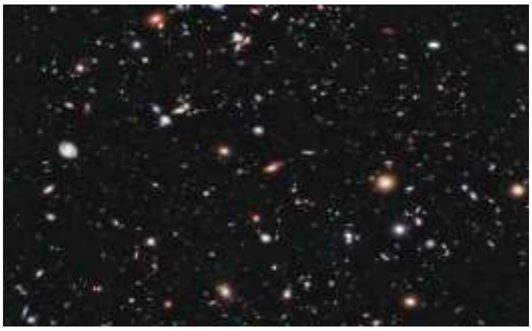


Fig1 : NASA, ESA, G. Illingworth, D. Magee, and P. Oesch (University of California, Santa)

Scientists have known for almost a century that the universe is expanding, with all of the galaxies flying apart from each other. And until recently, scientists believed that there were only two possible options for the universe in the future. It could expand forever (like the ball that you tossed upward at 25,000 miles an hour), but with the expansion slowing down as gravity pulled all of the galaxies toward each other. Or gravity might win out in the end and bring the expansion of the universe to a halt, finally collapsing it back down in a "big crunch," just like your ball plunging back to the ground.

From the start of big bang our universe is expanding. So it is logical to assume that the expansion will stop someday. Universe has its own momentum and energy by which it is expanding.

But someday it may stop and start to collapse due to the gravitational pull of the stars and galaxies.

Scientists are assuming that there is some force that is preventing our universe from collapsing into itself. In order to know that force we have to know the material our universe is made of. Some of us may think we have already known about the materials such as hydrogen, oxygen, electron, proton, neutron etc. But in reality we know very little of the composition of our universe.

Scientists know that our universe is expanding. But how fast? The question hasn't been answered yet. Without knowing this answer it is difficult to predict the fate of our universe. But why? What is the problem of finding the rate of some expansion?

Problems determining the speed of universe

It is very easy to measure speed of something in earth. We calculate the speed by estimating the time required for an object to reach some distance. But measuring the speed of universe is totally different. As light from some star takes millions of years to reach earth, by the time it reaches here the star may have long gone. And we cannot tell the distances it travelled with certainty as it is too far. So measuring the speed is a huge problem for the scientists.

Dark Energy, Dark Matter

In the early 1990s, one thing was fairly certain about the expansion of the Universe. It might have enough energy density to stop its expansion and recollapse, it might have so little energy density that it would never stop expanding, but gravity was certain to slow the expansion as time went on. Granted, the slowing had not been observed, but, theoretically, the Universe had to slow. The Universe is full of matter and the attractive force of gravity pulls all matter together. Then came 1998 and the Hubble Space Telescope (HST) observations of very distant supernovae that showed that, a long time ago, the Universe was actually expanding more slowly than it is today. So the expansion of the Universe has not been slowing due to gravity, as everyone thought, it has been accelerating. No one expected this, no one knew how to explain it. But something was causing it.

Eventually theorists came up with three sorts of explanations. Maybe it was a result of a long-discarded version of Einstein's theory of gravity, one that contained what was called a "cosmological constant." Maybe there was some strange kind of energy-fluid that filled space. Maybe there is something wrong with Einstein's theory of gravity and a new theory could include some kind of field that creates this cosmic acceleration. Theorists still don't know what the correct explanation is, but they have given the solution a name. It is called dark energy.

What Is Dark Energy?

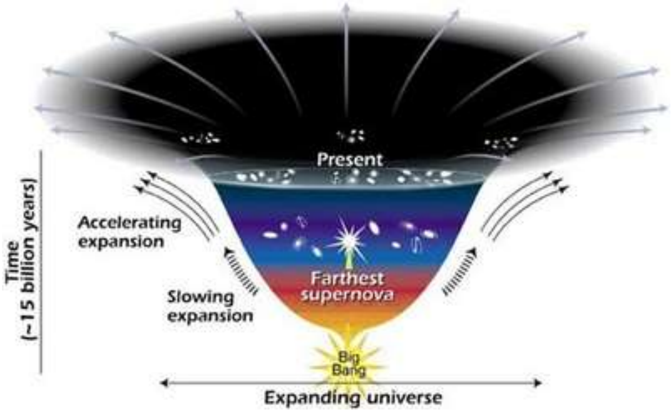


Fig 2: Universe Dark Energy-1 Expanding Universe

This diagram reveals changes in the rate of expansion since the universe's birth 15 billion years ago. The more shallow the curve, the faster the rate of expansion. The curve changes noticeably about 7.5 billion years ago, when objects in the universe began flying apart as a faster rate. Astronomers theorize that the faster expansion rate is due to a mysterious, dark force that is pulling galaxies apart.

More is unknown than is known. We know how much dark energy there is because we know how it affects the Universe's expansion. Other than that, it is a complete mystery. But it is an important mystery. It turns out that roughly 68% of the Universe is dark energy. Dark matter makes up about 27%. The rest - everything on Earth, everything ever observed with all of our instruments, all normal matter - adds up to less than 5% of the Universe. Come to think of it, maybe it shouldn't be called "normal" matter at all, since it is such a small fraction of the Universe.

One explanation for dark energy is that it is a property of space. Albert Einstein was the first person to realize that empty space is not nothing. Space has amazing properties, many of which are just beginning to be understood. The first property that Einstein discovered is that it is possible for more space to come into existence. Then one version of Einstein's gravity theory, the version that contains a cosmological constant, makes a second prediction: "empty space" can possess its own energy. Because this energy is a property of space itself, it would not be diluted as space expands.

As more space comes into existence, more of this energy-of-space would appear. As a result, this form of energy would cause the Universe to expand faster and faster. Unfortunately, no one understands why the cosmological constant should even be there, much less why it would have exactly the right value to cause the observed acceleration of the Universe.

Fig 3 : Dark Matter Core Defies Explanation

This image shows the distribution of dark matter, galaxies, and hot gas in the core of the merging galaxy cluster Abell 520. The result could present a challenge to basic theories of dark matter.

Another explanation for how space acquires energy comes from the quantum theory of matter. In this theory, "empty space" is actually full of temporary ("virtual") particles that continually form and then disappear. But when physicists tried to calculate how much energy this would give empty space, the answer came out wrong - wrong by a lot. The number came out 10^{120} times too big. That's a 1 with 120 zeros after it. It's hard to get an answer that bad. So the mystery continues.

Another explanation for dark energy is that it is a new kind of dynamical energy fluid or field, something that fills all of space but something whose effect on the expansion of the Universe is the opposite of that of matter and normal energy. Some theorists have named this "quintessence," after the fifth element of the Greek philosophers. But, if quintessence is the answer, we still don't know what it is like, what it interacts with, or why it exists. So the mystery continues.

A last possibility is that Einstein's theory of gravity is not correct. That would not only affect the expansion of the Universe, but it would also affect the way that normal matter in galaxies and clusters of galaxies behaved. This fact would provide a way to decide if the solution to the dark energy problem is a new gravity theory or not: we could observe how galaxies come together in clusters. But if it does turn out that a new theory of gravity is needed, what kind of theory would it be? How could it correctly describe the motion of the bodies in the Solar System, as Einstein's theory is known to do, and still give us the different prediction for the Universe that we need? There are candidate theories, but none are compelling. So the mystery continues.

The thing that is needed to decide between dark energy possibilities - a property of space, a new dynamic fluid, or a new theory of gravity - is more data, better data.

What Is Dark Matter?

Fig 4: Abell 2744: Pandora's Cluster Revealed

One of the most complicated and dramatic collisions between galaxy clusters ever seen is captured in this new composite image of Abell 2744. The blue shows a map of the total mass concentration (mostly dark matter).

By fitting a theoretical model of the composition of the Universe to the combined set of cosmological observations, scientists have come up with the composition that we described above, ~68% dark energy, ~27% dark matter, ~5% normal matter. What is dark matter?

We are much more certain what dark matter is not than we are what it is. First, it is dark, meaning that it is not in the form of stars and planets that we see. Observations show that there is far too little visible matter in the Universe to make up the 27% required by the observations. Second, it is not in the form of dark clouds of normal matter, matter made up of particles called baryons. We know this because we would be able to detect baryonic clouds by their absorption of radiation passing through them. Third, dark matter is not antimatter, because we do not see the unique gamma rays that are produced when antimatter annihilates with matter. Finally, we can rule out large galaxy-sized black holes on the basis of how many gravitational lenses we see. High concentrations of matter bend light passing near them from objects further away, but we do not see enough lensing events to suggest that such objects to make up the required 25% dark matter contribution.

However, at this point, there are still a few dark matter possibilities that are viable. Baryonic matter could still make up the dark matter if it were all tied up in brown dwarfs or in small, dense chunks of heavy elements. These possibilities are known as massive compact halo objects, or "MACHOs". But the most common view is that dark matter is not baryonic at all, but that it is made up of other, more exotic particles like axions or WIMPS (Weakly Interacting Massive Particles)

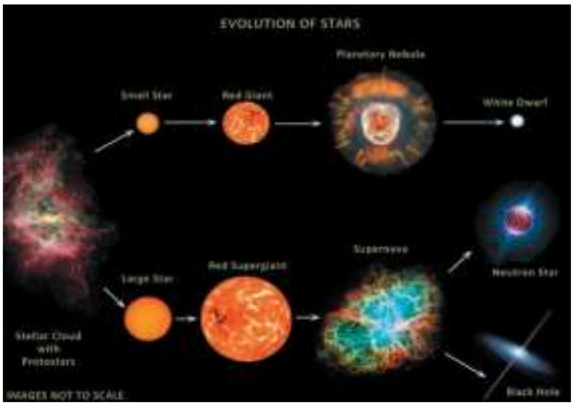


Fig 5: Evaluation of stars

For stars less than about eight times the mass of our sun, the destruction begins when the outer layers are thrown off into space and the core flares brightly, forming a ring of expanding gas called a planetary nebula. The name planetary nebula is misleading because it is not related to planets. But it does have the cloud-like nature of other nebulae. The name came about because astronomers using very early telescopes thought that the clouds resembled the planets Uranus and Neptune. The remaining star fades to become a white dwarf, typically about the size of the Earth but with a very high density and a surface temperature of about 12 000 °C. It then slowly cools, becomes a cold black dwarf and disappears from view.

Galaxies

Stars group together in groups to form galaxies, attracted towards each other by gravitational forces. Our own sun is one of an estimated 200–400 billion stars in the Milky Way galaxy. We think there are more than 100 billion other galaxies of different sizes and shapes throughout the universe. Each of these galaxies is home to stars at all stages of their life cycles. The Milky Way galaxy, shown at right, is a spiral galaxy. Our solar system is found on the Orion arm of the spiral. Due to the rotation of the galaxy, our solar system orbits the centre of the galaxy at a speed of about 200 kilometers per second.

Mapping the universe

In 1989, a satellite named COBE (COsmic Background Explorer) was put into orbit around Earth to accurately measure the background radiation and temperature of the universe. COBE could detect variations as small as 0.000 03 °C. As predicted by Gamow, it detected an average temperature of −270 °C. In 2001, a probe called WMAP (Wilkinson Microwave Anisotropy Probe) was sent into orbit around Earth at a much greater distance to gather even more accurate data, detecting temperatures within a millionth of a degree. WMAP’s first images were released by NASA in February 2003. The computerenhanced image of cosmic microwave background radiation shown below left was produced by the WMAP mission. The background radiation detected was released only 380 000 years after the big bang — the first radiation to escape. The image shows how the temperature varied across the universe as it was 380 000 years after the big bang. The blue parts of the map are the cooler regions. These regions were cool enough for atoms, and eventually galaxies, to form. The red parts are warmer regions. The map shows that galaxies are not evenly spread throughout the universe. They support the theory of an expanding universe that began with a big bang.

Will it ever end?

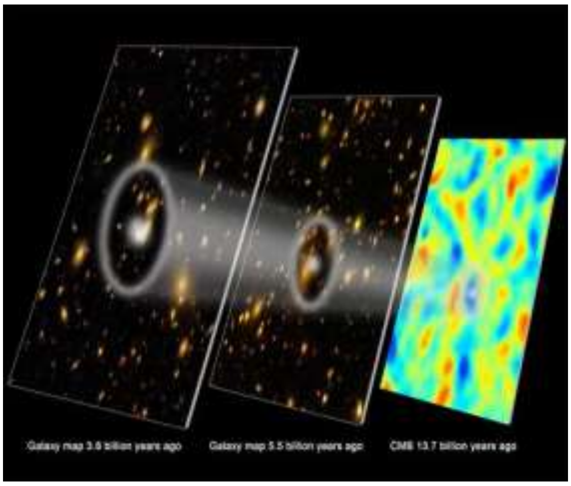
Will the expansion of the universe continue forever? If the universe does stop expanding, what will happen to it? There are several competing theories about the answers to these questions. One theory suggests that there is not enough mass in the universe for gravity to be able to pull it all back, so it will continue to expand forever. Other theories suggest that the universe will eventually end. According to these theories, the end will come when the universe snaps back onto itself in a ‘big crunch’ (the big crunch theory). If this happens, the end result will be a single point — singularity. Some cosmologists believe that the big crunch will be followed by another big bang.

CONCLUSION

New Data. In 2012 after a two-year study, scientists at the University of Portsmouth in the United Kingdom and LM University in Munich, Germany have concluded that the likelihood of dark energy's existence stands at 99.996 percent. In 1967, Rainer Sachs and Arthur Wolfe theorized that light from the CMB that was left over from the Big Bang would become slightly more blue as it passed through galaxy clusters in space because of the influence of the cluster's strong gravitational fields (gravitational blueshift). This phenomenon is now called the Integrated Sachs-Wolfe (ISW) effect.

Gravitational Red shift/Blue shift. Gravitational red shift occurs for fundamentally the same reason that projectiles on earth slow down when rising - because they have to transfer kinetic energy (speed) into potential energy (height). Projectiles, such as a cannon ball, do this by slowing down. Photons, however, cannot slow down as they are constrained to always travel at exactly "c", the speed of light. A photon sheds its kinetic energy "going through" a gravitational well (a void in the universe, almost no gravity) by lowering its frequency. A lower frequency means a longer, "redder" wavelength. The opposite process occurs when a photon is "coming out of " a gravitational well (i.e. passing through a galaxy cluster). The photon trades potential energy for kinetic energy and gains in frequency which shortens its wavelength to become more "blue", a blueshift. As photons pass in and out of space voids and galaxy clusters, the redshifts and blueshifts should normally cancel out.

However, if dark energy is present in a our universe, a very slight ISW effect should be detected in the CMB here on earth. In a very large void in space, the photon's trip out would be slightly longer than the trip in because the void would have expanded slightly due to the "push" from dark energy. Therefore the photon would be stretched and be redshifted. The opposite occurs passing through a large galaxy. The photon would gain energy and be blueshifted. However, we are talking about a photon at the speed of light, and the ISW effect would be so very tiny as to be non-dectable directly by any of today's technology. The only possible way to detected such a tiny shift would be to statistically average the results over many observations from many different galaxies and voids at very large distances. The ISW question becomes "look at the CMB and check whether or not on average it is bluer in patches of the sky that have more matter behind them and redder in patches where there is less matter". Matter means both visible matter and dark (transparent) matter.



Strong Evidence.

In 1996, astronomers Robert Crittenden and Neil Turok suggested that overlaying maps of the local universe on the map of the residual CMB radiation could provide clues as to where to look for the ISW effect. In 2003, ISW was discovered but it was very, very weak. Yet "Science Magazine" recognized it as being very significant and called it the "2003 Breakthrough Of The Year". However, some scientists argued that it could have been caused by cosmic dust and/or other phenomenon questioning "the discovery".

Recently the Anglo/German team that carried out the initial study was again led by Robert Crittenden and Tommaso Giannantonio. They re-examined all the arguments against the ISW detection and improved the maps and data used in the original work. After a two year study, they concluded that dark energy is almost certainly responsible for the "hotter" differences of the cosmic microwave background. In September of 2012, they announced "We have methodically addressed all of the counter issues and concluded that none of them can explain the observations we see. The probability of dark energy's existence is indeed 99.996 percent" (or the same level of significance as the recent discovery of the Higgs boson). See the Dark Energy Is Real article.

REFERENCES

1. Avni, Yoram: Energy Spectra of X-Ray Clusters of Galaxies. Institute of Astronomy, Cambridge, England. (May 3, 1976)
2. Bennett, C. L., et al.: Wilkinson Microwave Anisotropy Probe (WMAP) Observations: Preliminary Maps and Basic Results. Astrophysical Journal (2003)
3. Hawley, John F. and Katherine A. Holcomb Foundations of Modern Cosmology 1998: Oxford University Press, NY.
4. Hubble, E. Proc. National Academy of Science USA **15** 168-173. (1929) [5] Nickalls, R. W. D.: A new approach to solving the cubic: Cardan's solution revealed. The Mathematical Gazette. **77** (1993)
5. Perlmutter, Saul and Brian P. Schmidt: Measuring cosmology with Supernovae. Lecture Notes in Physics (March 18, 2003)
6. Perlmutter, Saul, et al.: Supernovae, Dark Energy, and the Accelerating Universe. Physics Today. **56**: 53 - 60. (April 2003)
7. Ryden, Barbara Introduction to Cosmology: Addison Wesley, CA. (2003)
8. Tonry, John L.,et al.: Cosmological Results from High-z Supernovae. Astrophysical Journal. **1** (May 1, 2003)